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## ***SUPPLEMENTARY MATERIAL for***

# **Evaluation of Fenton and modified Fenton oxidation coupled with membrane distillation for produced water treatment: Benefits, challenges, and effluent toxicity**

Giulio Farinelli,<sup>†,1</sup> Marco Coha,<sup>†,1</sup> Marco Minella,<sup>§</sup> Debora Fabbri,<sup>§</sup> Marco Pazzi,<sup>§</sup> Davide Vione,<sup>§</sup> Alberto Tiraferri<sup>†,\*</sup>

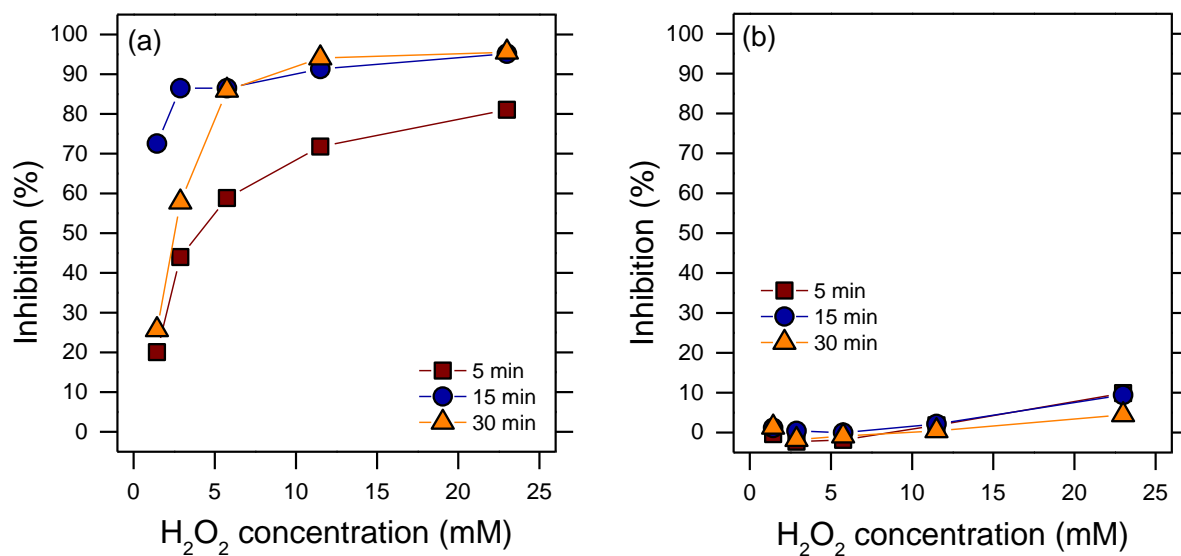
<sup>†</sup>Department of Environment, Land and Infrastructure Engineering (DIATI), Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129, Turin (Italy)

<sup>§</sup>Department of Chemistry, Università di Torino, Via Pietro Giuria 5, 10125 Turin (Italy)

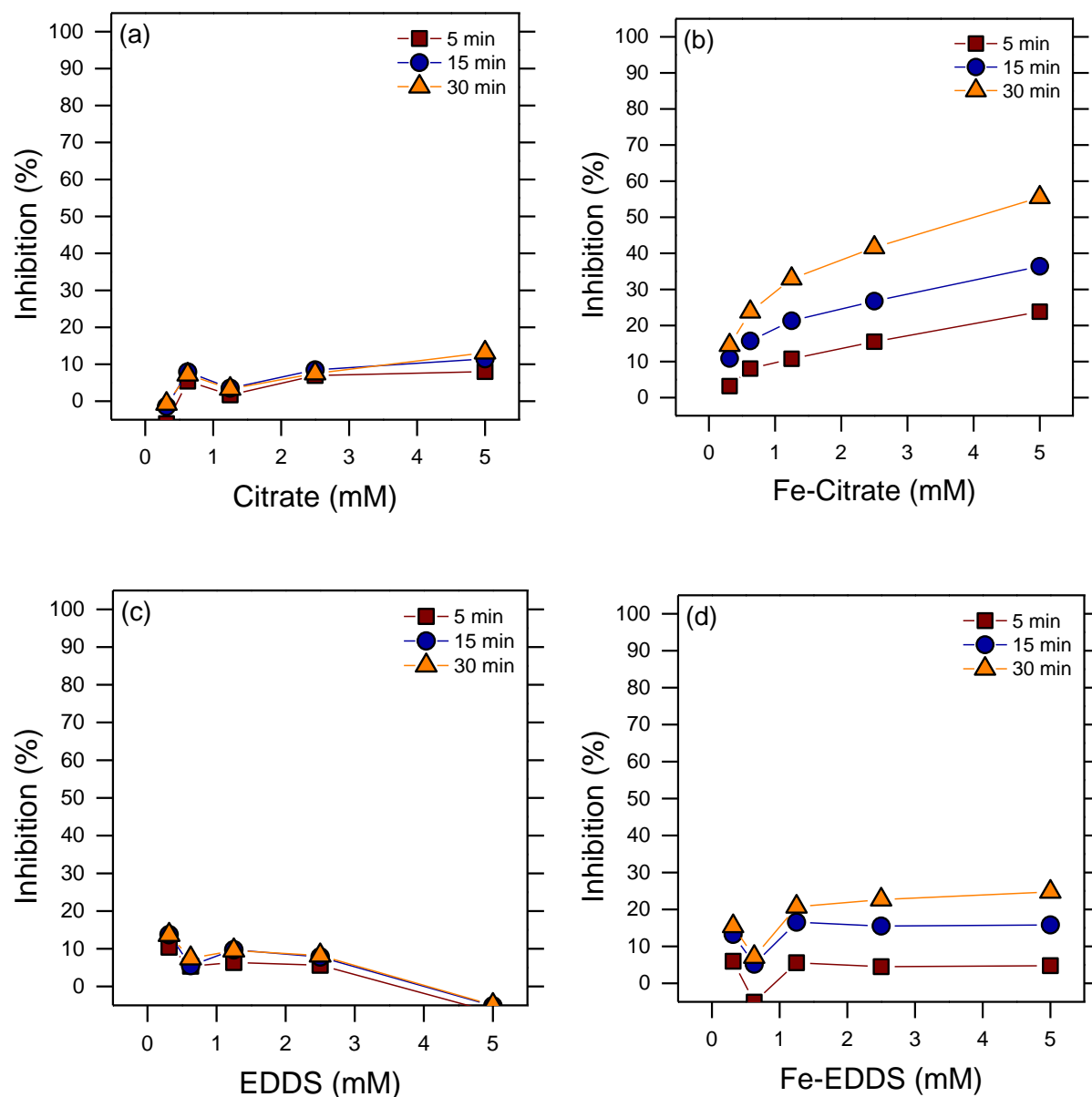
\* Corresponding Author:

A. T. Email: [alberto.tiraferri@polito.it](mailto:alberto.tiraferri@polito.it); Phone: +39 (011) 090-7628

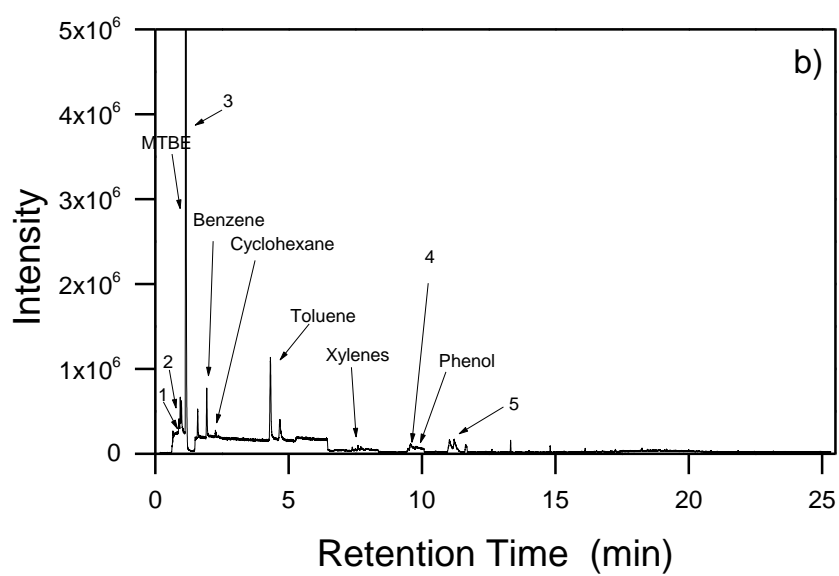
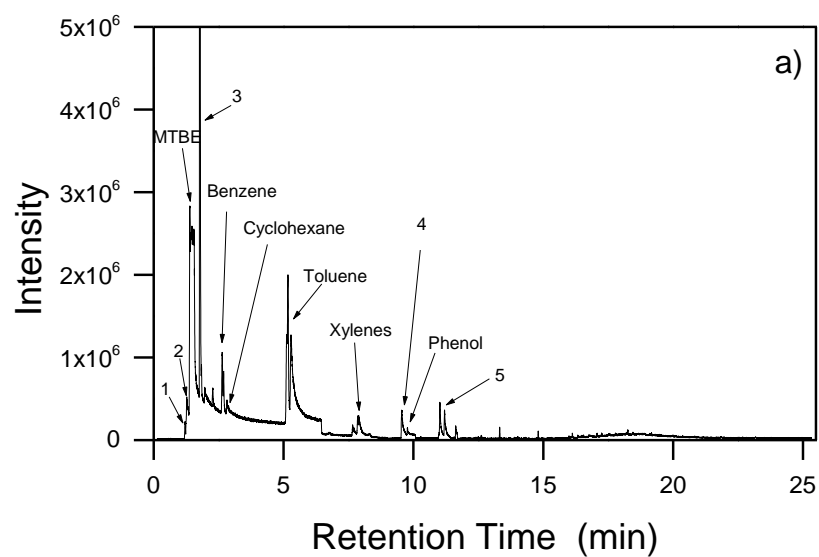
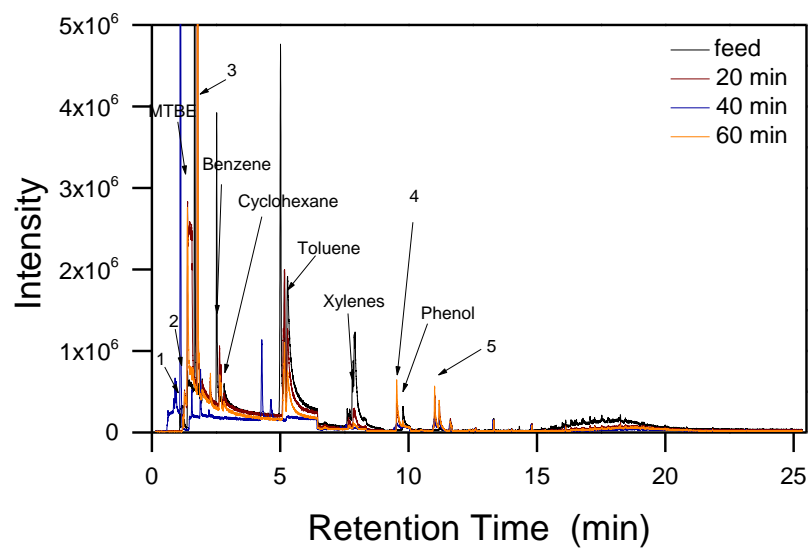
<sup>1</sup> These authors contributed equally

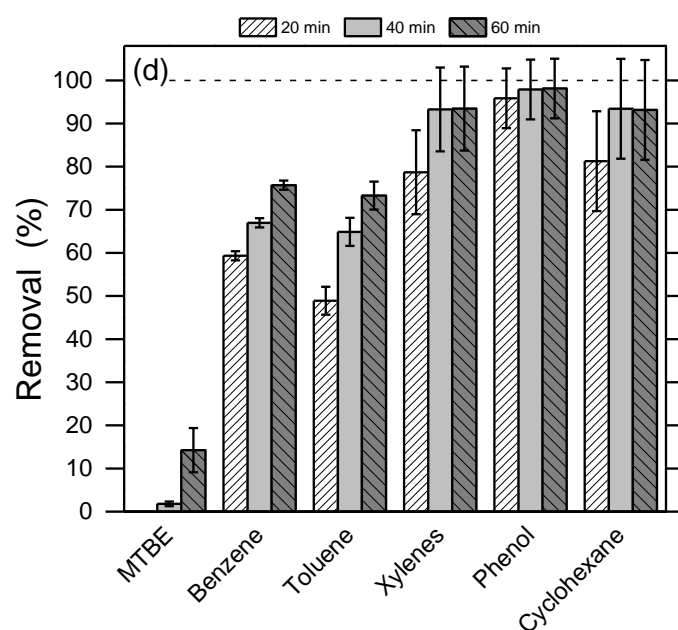
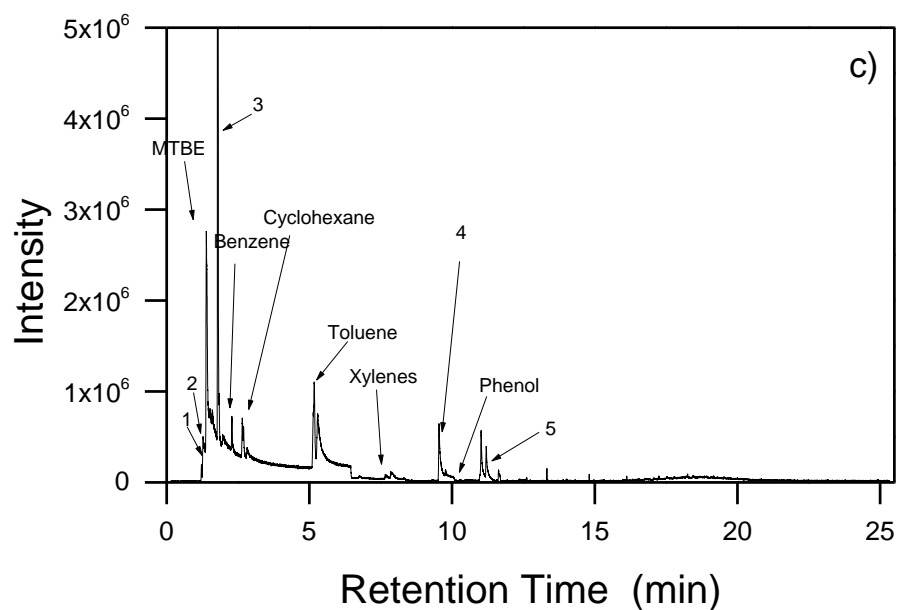


**Figure S1** (a) Effect of hydrogen peroxide on bioluminescence . (b) Effect of hydrogen peroxide quenched with catalase. The acute toxicity was measured after 5, 15, and 30 minutes of contact (in red, blue, and orange, respectively) with the *Vibrio Fischeri* culture.

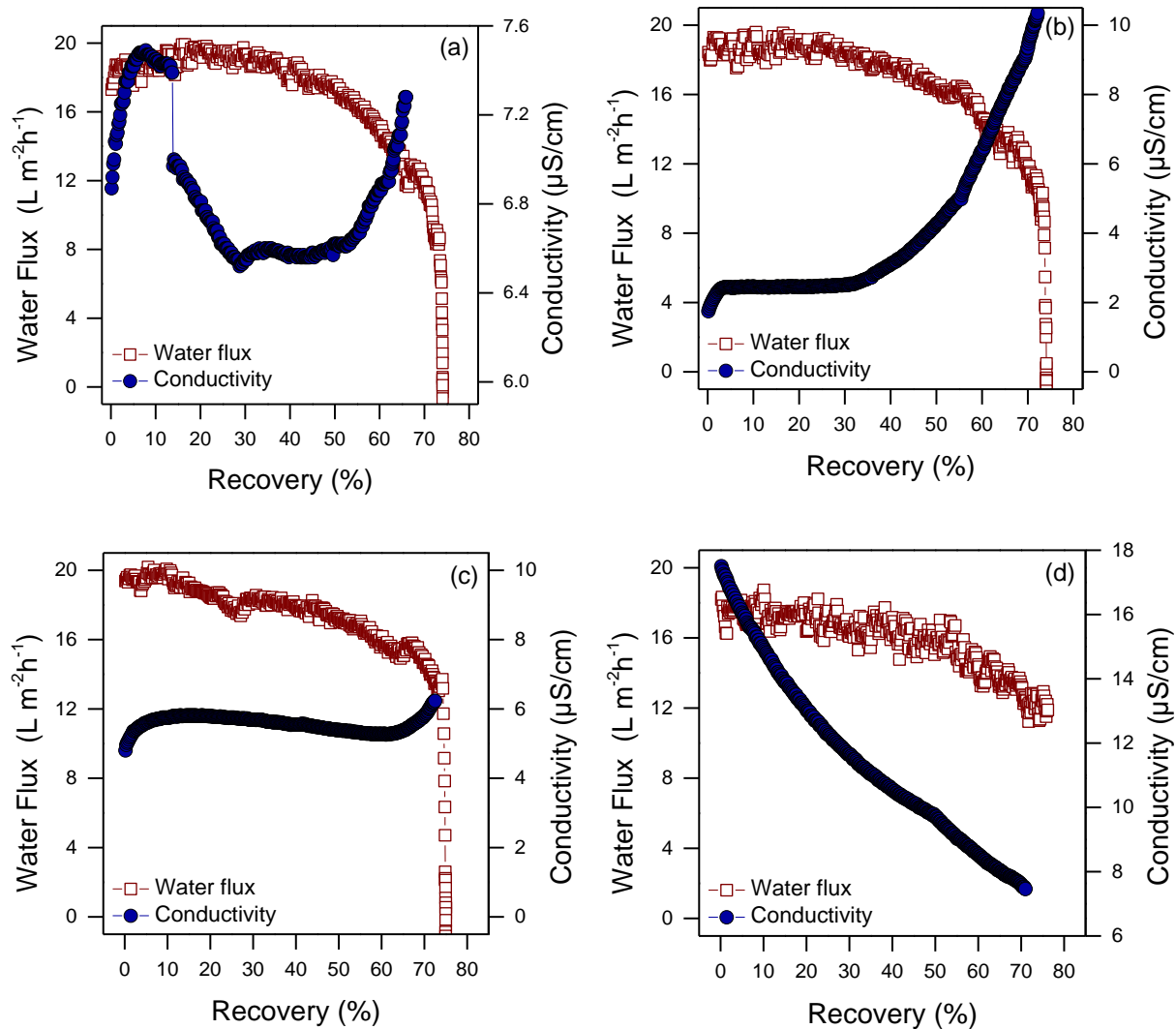


**Figure S2** Toxicity curves of (a) citrate, (b) Fe-citrate system, (c) EDDS, and (d) the Fe-EDDS system as a function of concentration. The toxicity was measured after 5, 15, and 30 minutes of contact (in red, blue, and orange, respectively) with the *Vibrio Fischeri* culture.

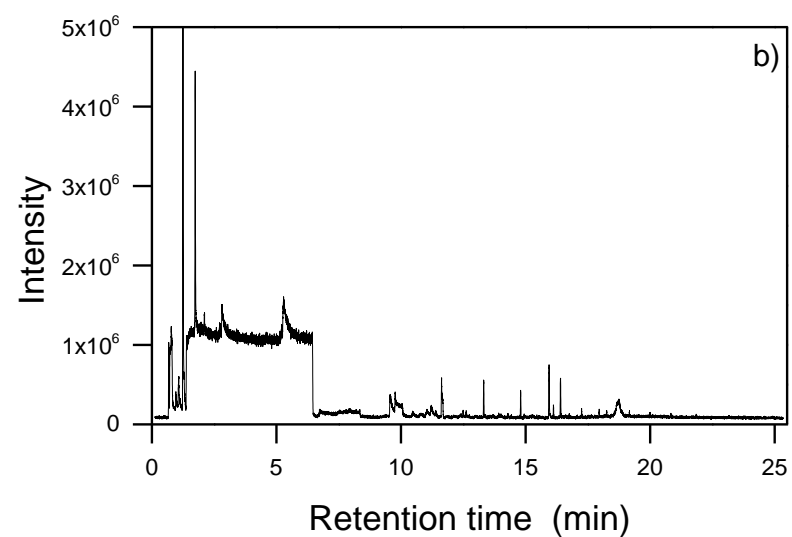
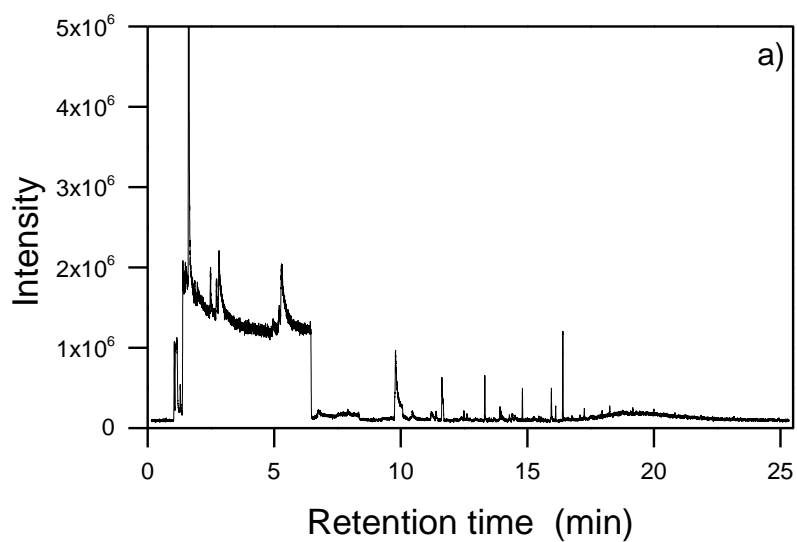
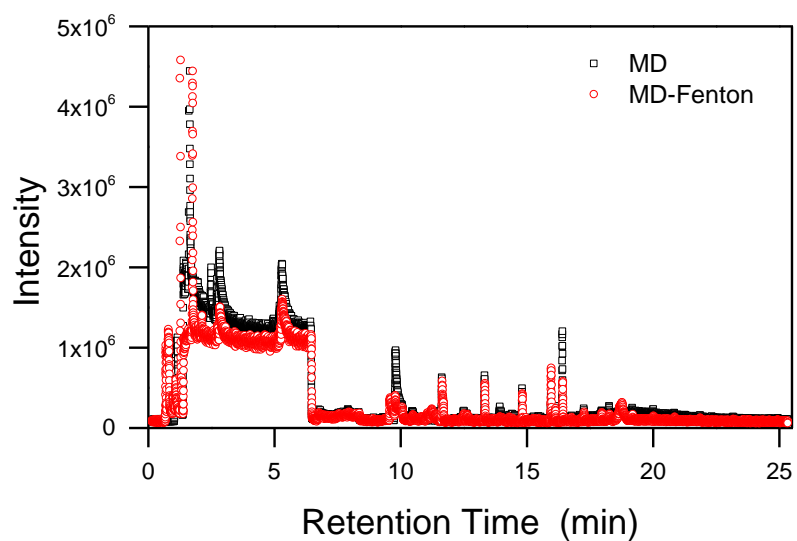




**Figure S3** Chromatograms of the solutions upon Fenton oxidation carried out for (a) 20, (b) 40, and (c) 60 minutes. The numbers are related to the by-products illustrated in Figure 1 of the main manuscript. All the non-targeted are column related compounds. (d) Degradation rate of each organic compound in the synthetic produced water after 20, 40, and 60 minutes of Fenton treatment.

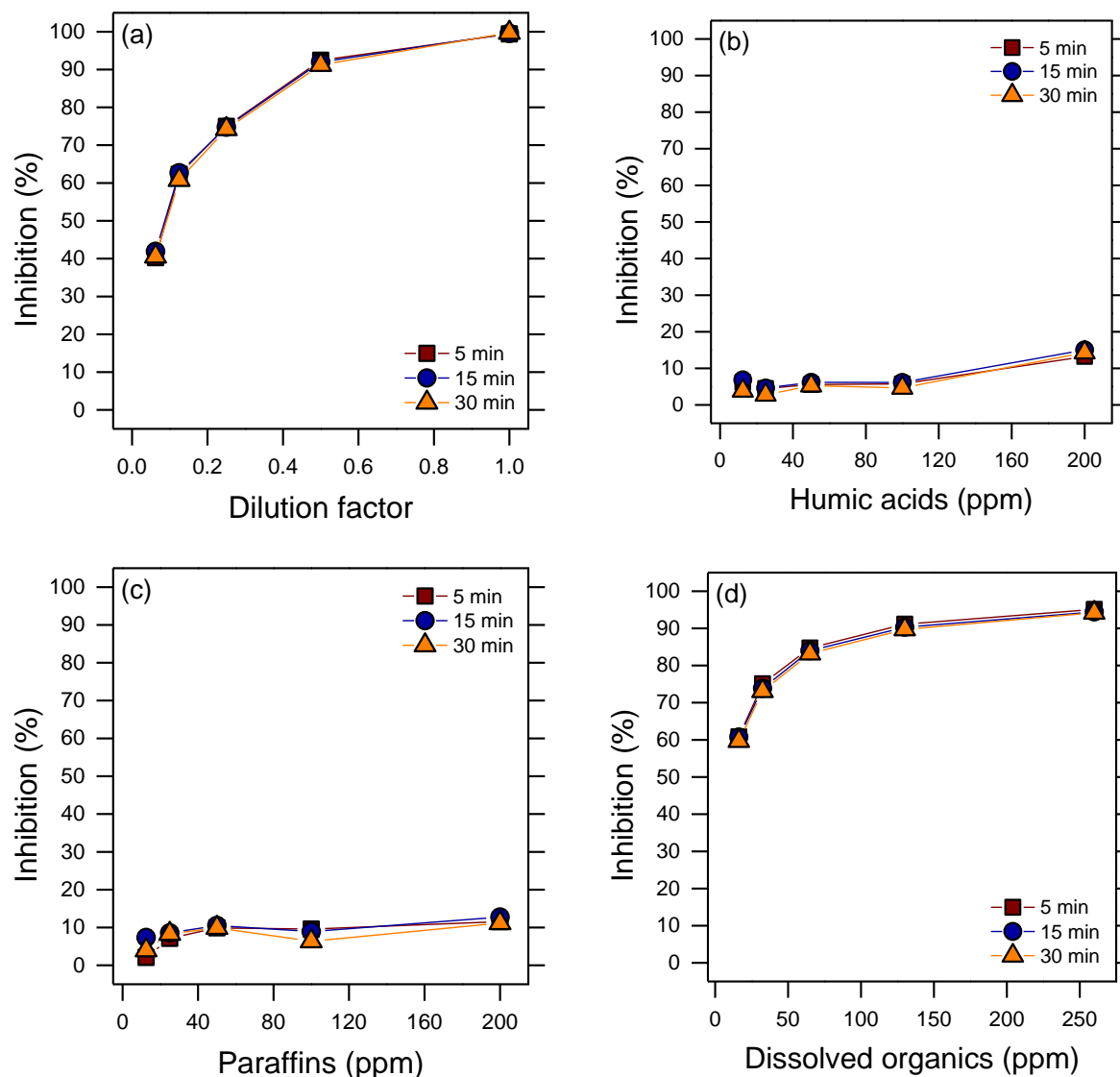


**Figure S4** Water flux and conductivity of the distillate tank during the membrane distillation of (a) the synthetic produced water, (b) the synthetic produced water pre-treated with Fenton oxidation, (c) the salts of the synthetic produced water and (d) the organics of the synthetic produced water.

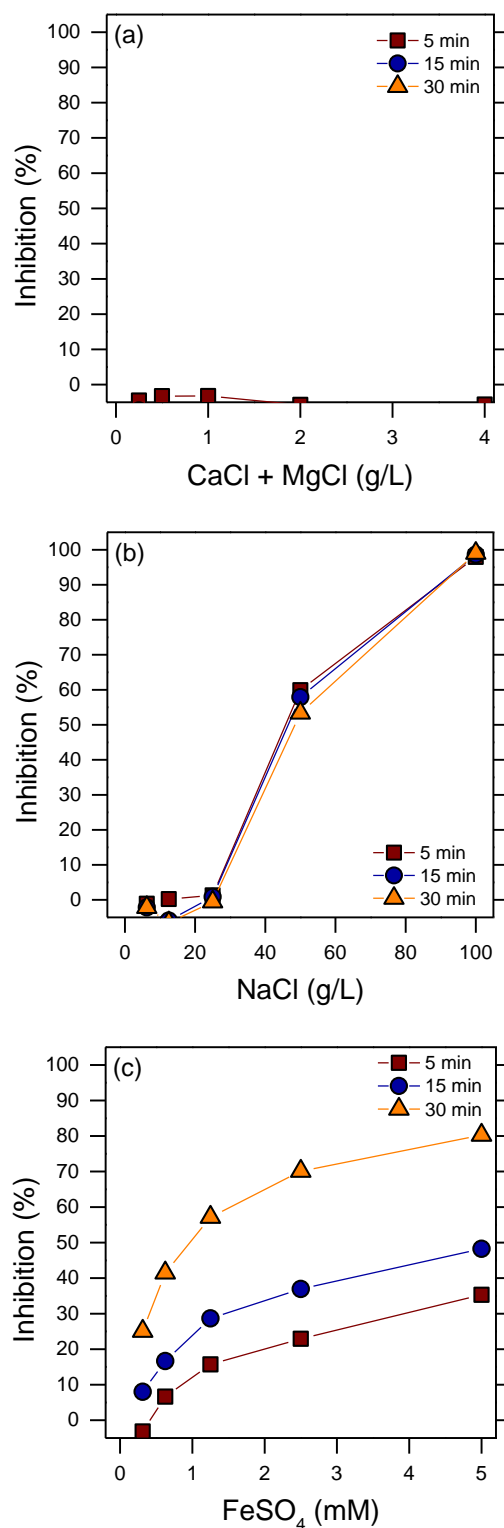


**Figure S5** (a) Chromatogram of the final effluent after treatment with membrane distillation. (b) Chromatogram of the final effluent after treatment with both Fenton and membrane distillation.

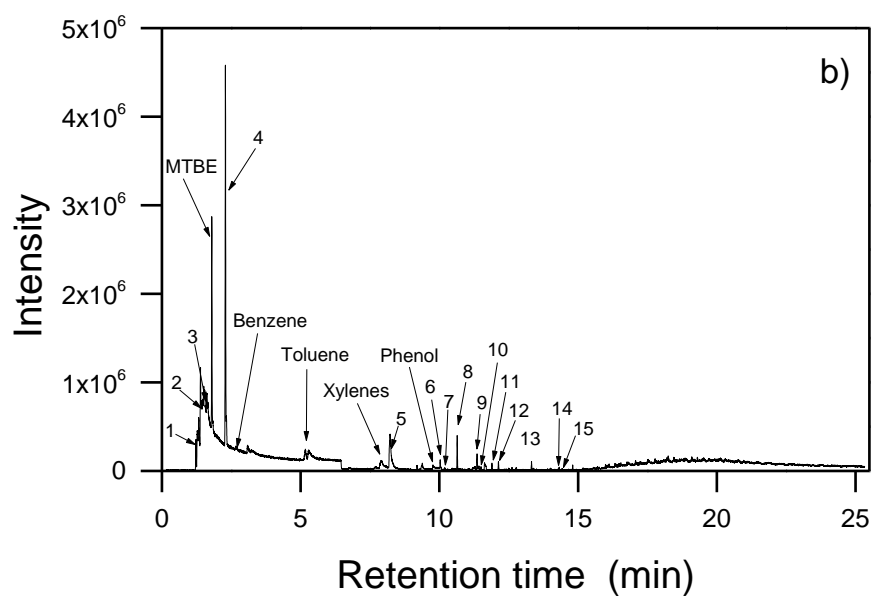
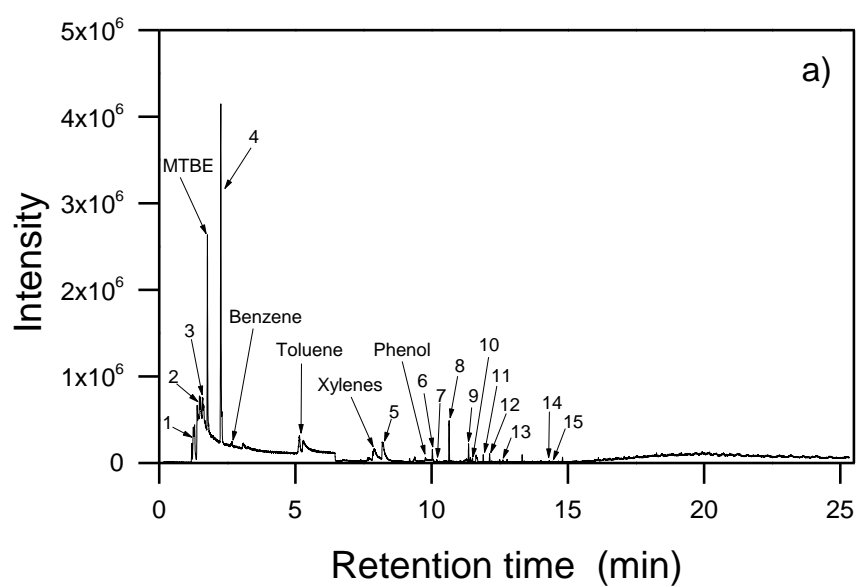
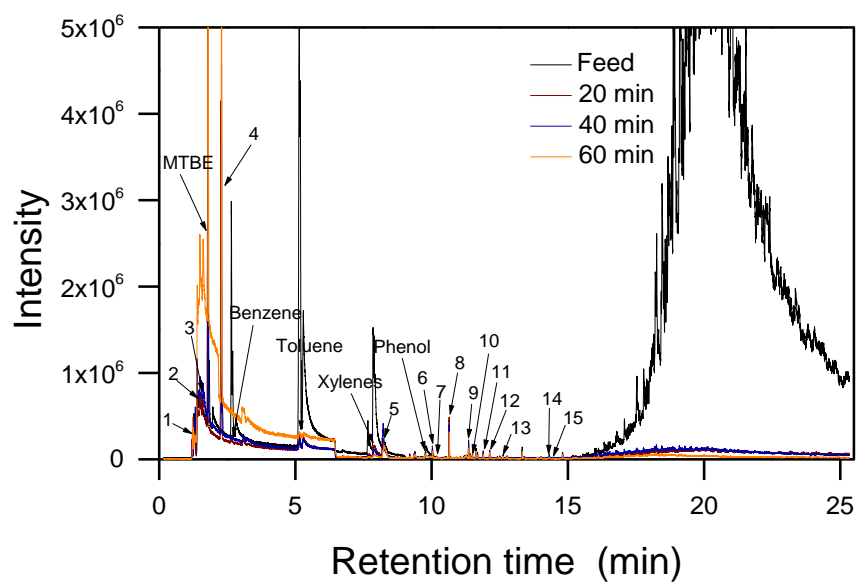


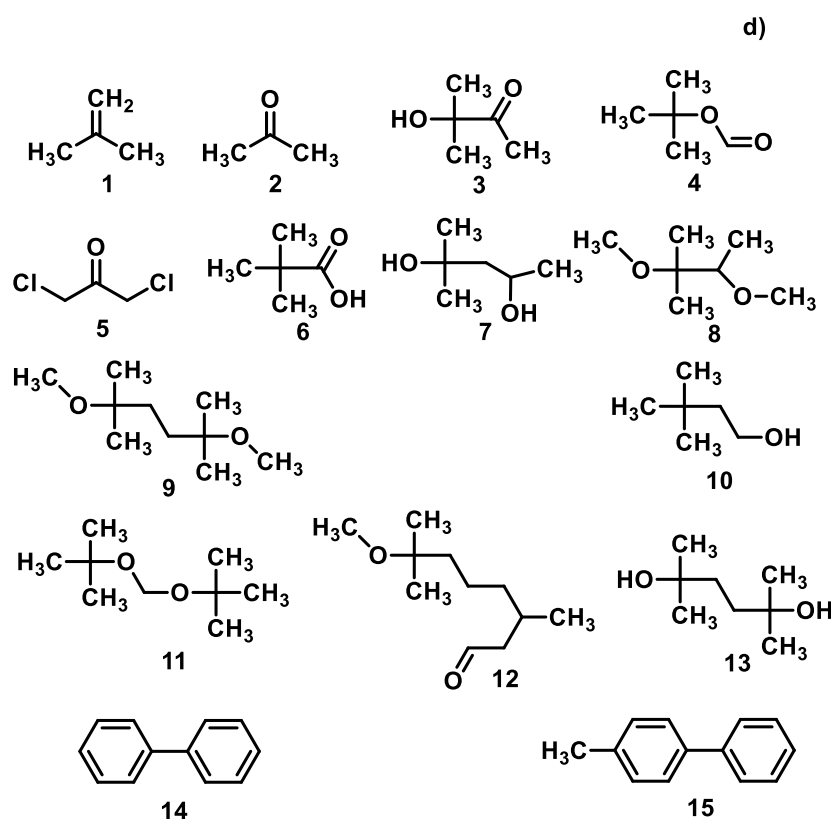
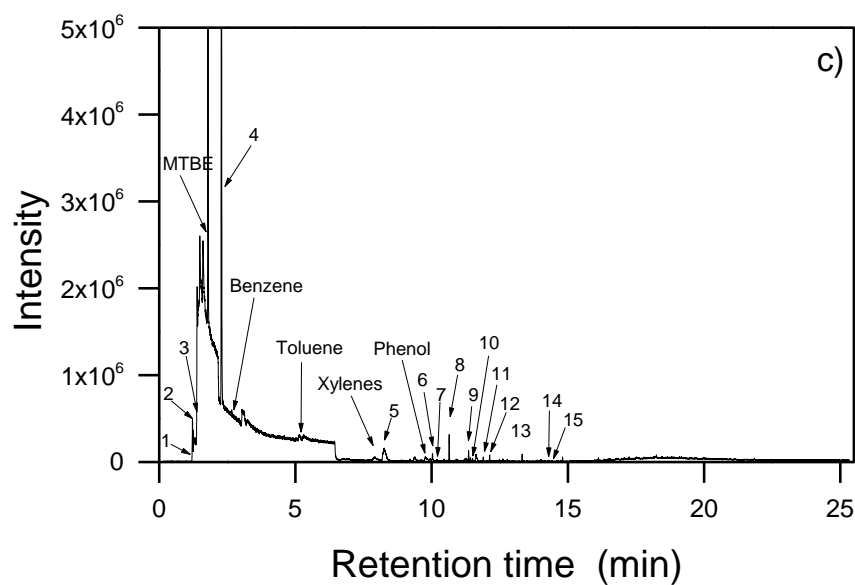


**Figure S6** Toxicity curves of the (a) non-treated synthetic produced water, (b) humic acids, (c) paraffins, and (d) dissolved organic compounds as a function of concentration. The toxicity was measured after 5, 15, and 30 minutes of contact (in red, blue, and orange, respectively) with the *Vibrio Fischeri* culture.

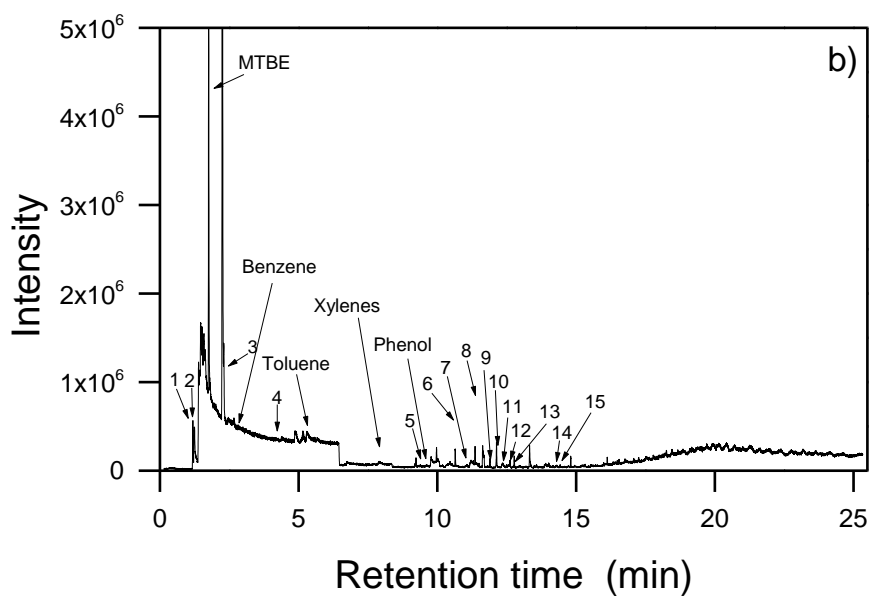
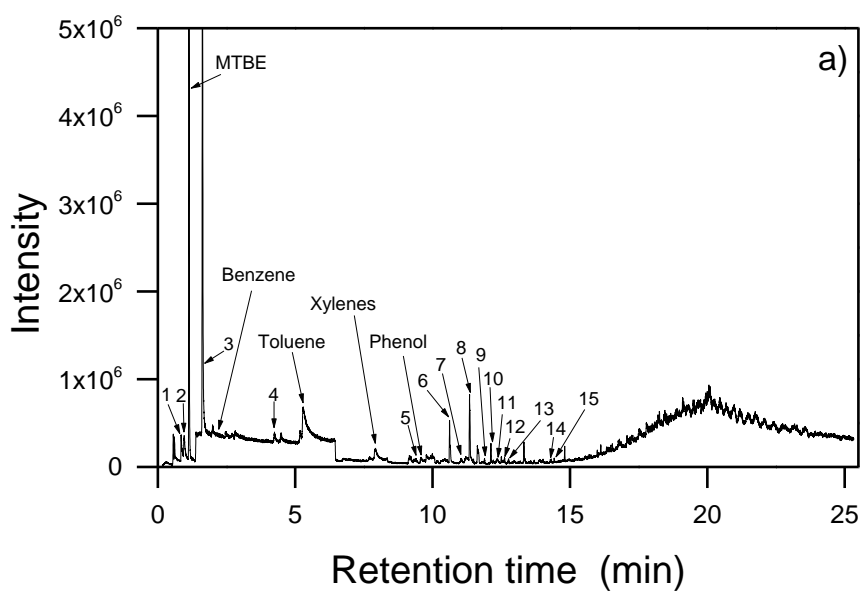
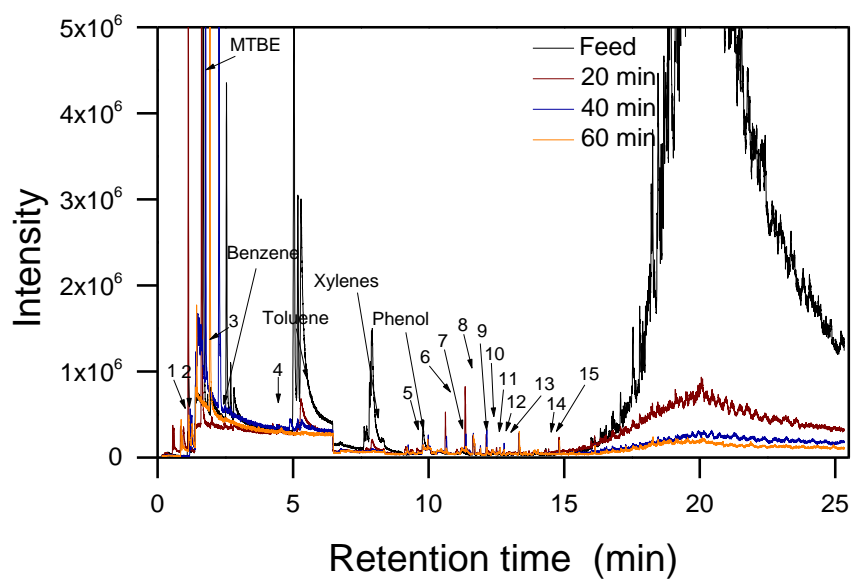


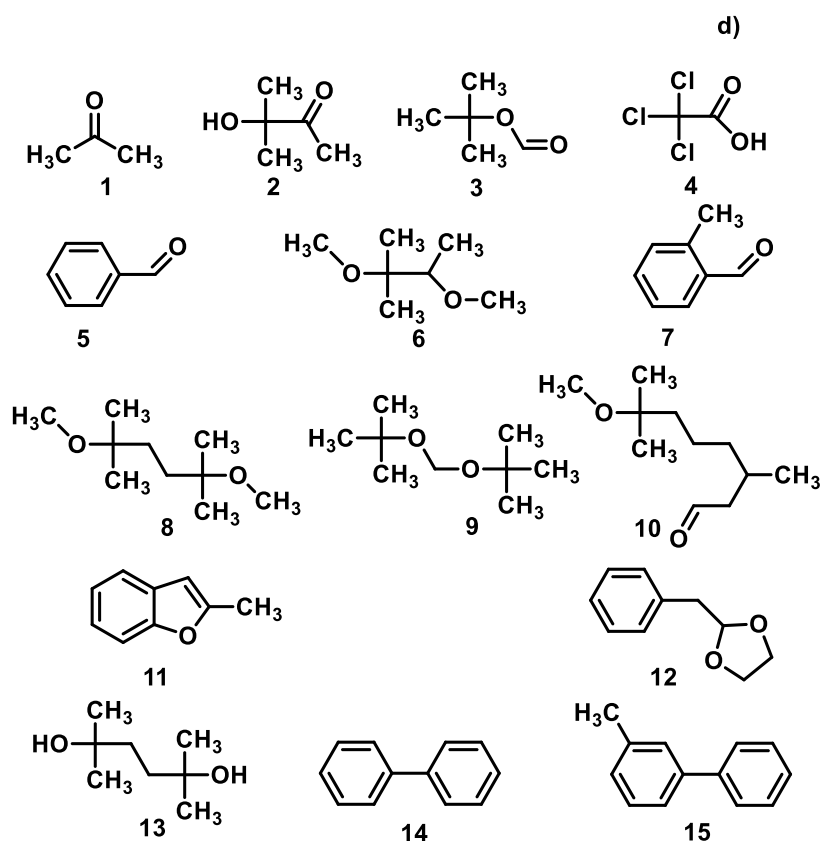
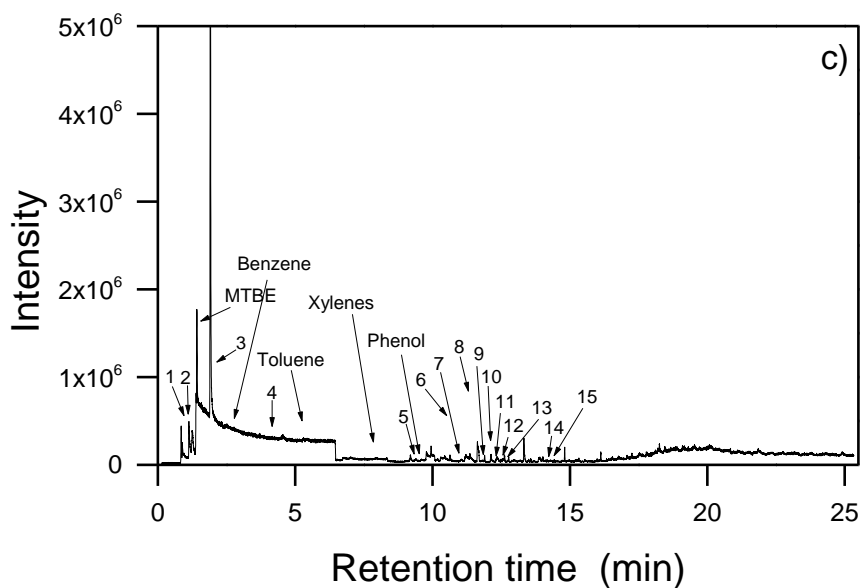
**Figure S7** Toxicity curves of (a) calcium and magnesium, (b) sodium chloride, and (c) iron sulfate as a function of concentration. The toxicity was measured after 5, 15, and 30 minutes of contact (in red, blue, and orange, respectively) with the *Vibrio Fischeri* culture.



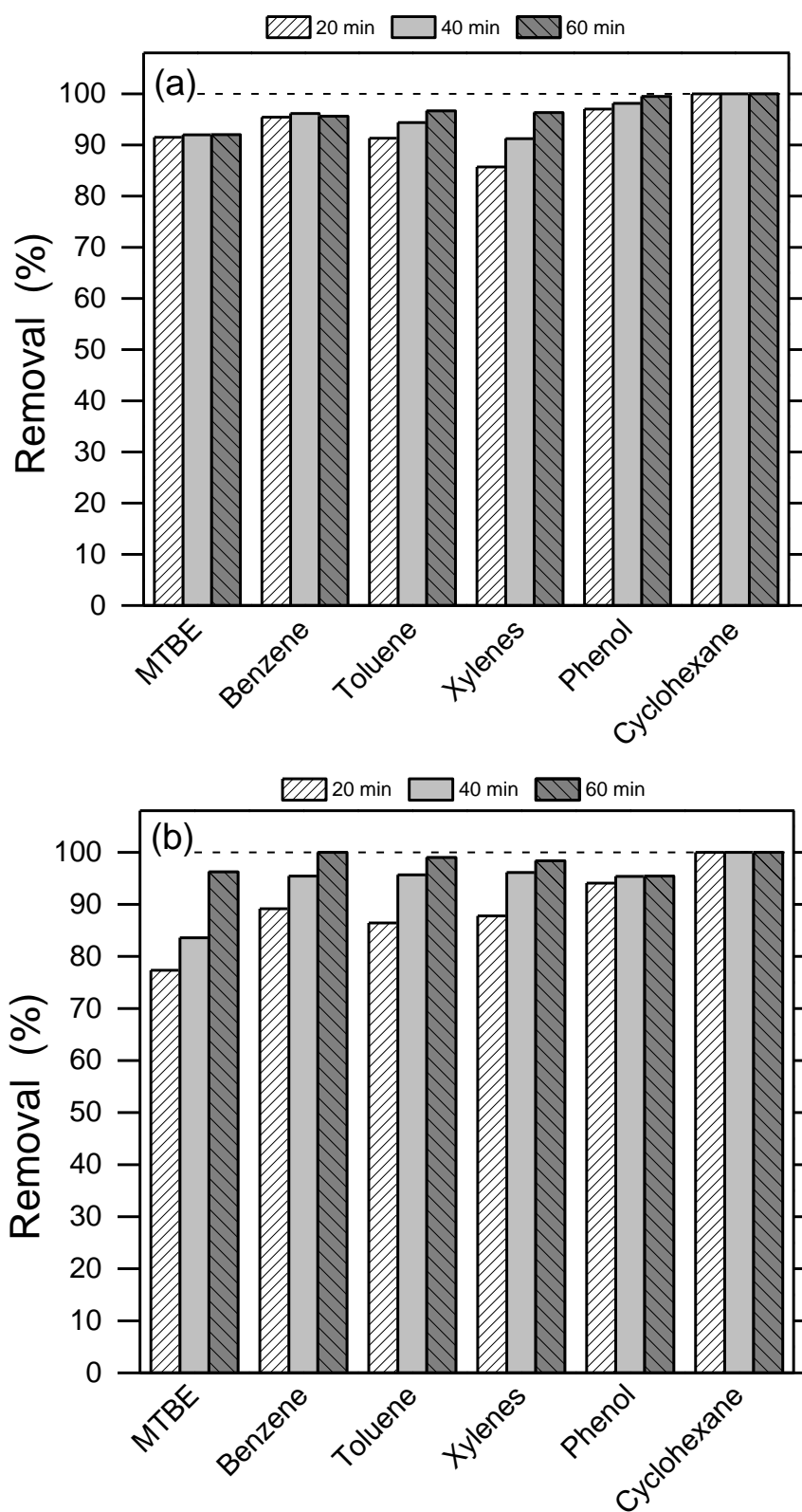


**Figure S8** Chromatograms of the solution after treatment by the Fe-citrate oxidation system after (a) 20, (b) 40, and (c) 60 minutes. The numbers are related to the by-products detected and illustrated in (d). All the non-targeted are column related compounds. (d) Chemical structures of the residual by-products adsorbed onto the fiber during the SPME extraction and detected by GC-MS at the end of the reaction with the Fe-citrate system as catalyst.

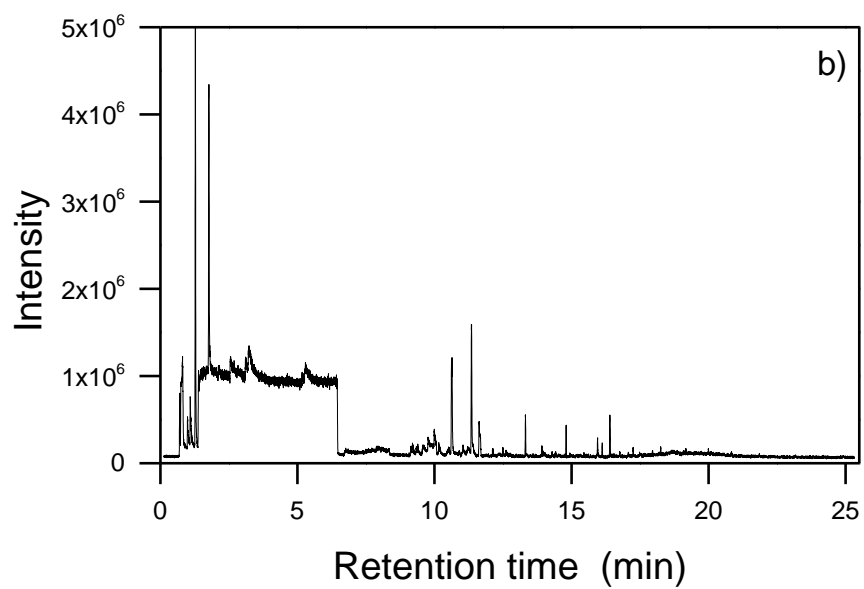
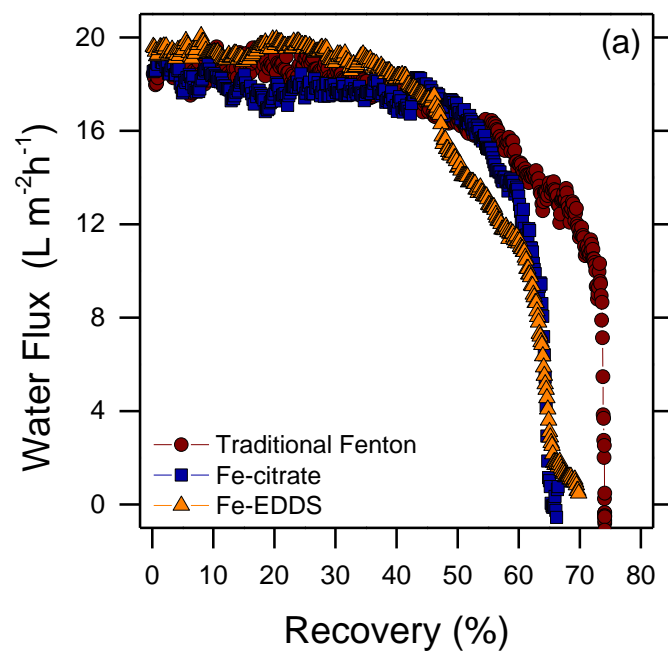




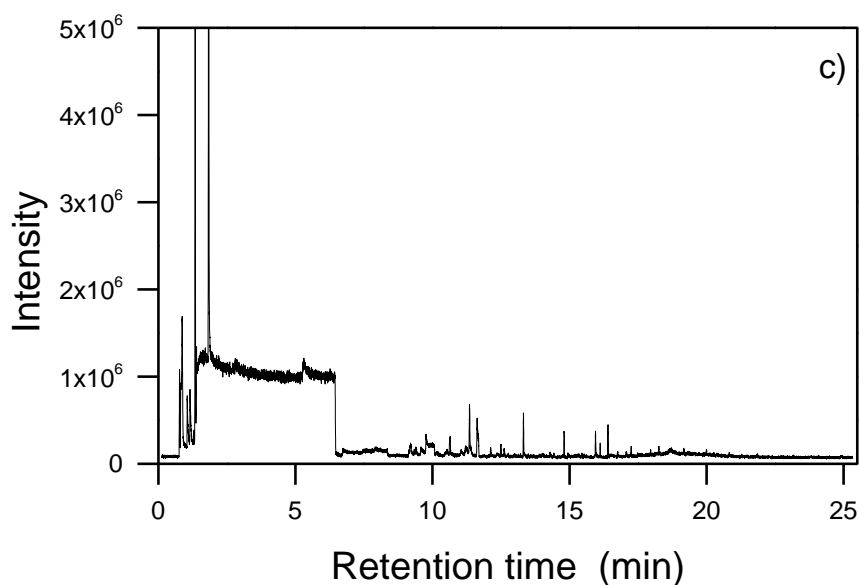
**Figure S9** Chromatograms of the solution after treatment by the Fe-EDDS oxidation system after (a) 20, (b) 40, and (c) 60 minutes. The numbers are related to the by-products detected and illustrated in (d). All the non-targeted are column related compounds. (d) Chemical structures of the residual by-products adsorbed onto the fiber during the SPME extraction and detected by GC-MS at the end of the reaction with Fe-EDDS system as catalyst.



**Figure S10** (a) Degradation rate of various organic compounds after 20, 40, and 60 minutes of modified Fenton treatment with (a) the Fe-citrate system and the (b) Fe-EDDS system.







**Figure S11** (a) Results of the MD filtration tests at high water recovery with different feed solutions: feed solution pre-treated by (red circles) traditional Fenton process, (blue squares) Fe-citrate system, and (orange triangles) Fe-EDDS system. Chromatograms of the final effluent after treatment with both modified-Fenton and membrane distillation for the (b) Fe-citrate oxidation pre-treatment and (c) Fe-EDDS oxidation pre-treatment. Please note that the lower recovery in the case of Fe-citrate and Fe-EDDS systems is imputable to the lower initial volume of feed, namely ~1.7 L rather than ~1.9 L as in Fenton system. A lower volume stopped the process before since the pump was not able anymore to take feed solution.